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"TECHNOLOGY CHANGE IN THE PHILIPPINE AGRICULTURAL MACHINERY INDUSTRY"

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ABSTRACT

Preliminary analysis has been done on a survey sample of 47 Philippine agricultural machinery manufacturers to investigate the nature of product changes made and to determine the characteristics of innovative firms. A wide variety of changes have been instituted showing considerable product differentiation and adaptation to local agricultural conditions. Several measures of direct and indirect technical change activity were found to be correlated with the number of product changes made.

INTRODUCTION

An important element in the process of economic development is the systematic improvement of production technology. The industrialized nations are correctly viewed as a valuable source of technology on which less developed nations (LDCs) can draw. The direct application of foreign technology in LDCs is subject to several limitations, however. First, the physical and technical LDC environment in which the technology must function, including climate and the quality and availability of inputs, may be significantly different from the environment for which the technology was intended. These differences can reduce a technology's performance below expectations or make it technically unviable. Second, an imported technology may be economically unsuitable because relative prices are different in the LDC, making a technically superior technology economically less profitable than the existing technology.

One response to these limitations of foreign technology has been to develop "appropriate" technology for LDCs. This movement has had some success. It must be remembered, however, that LDCs are far from a homogenous group, and it is unlikely that any given technology will be suitable in all economies and under all LDC conditions. Some regional, or in some cases national or local, adaptation must be made even to "appropriate" technologies. The need for local adaptation is nowhere more evident than in agricultural machinery, because of the great variety of agricultural conditions found even within a single country. This study, therefore, looks at the capacity of individual agricultural machinery manufacturers in the Philippines to make adaptive product improvements.

DESCRIPTION OF SAMPLE FIRMS

Between January and August, 1981, the authors conducted site visits and interviews with 47 agricultural machinery manufacturing firms. Twenty-seven of the firms constitute the population which have participated actively in the Industrial Extension Program of the International Rice Research Institute's (IRRI) Agricultural Engineering Department. Under this program, they have received one or more machinery designs developed at IRRI and have produced at least one of these designs on a commercial basis. In most cases, these firms have also been assisted by IRRI engineers in machinery testing, product improvement and production management. The remaining 20 firms have not been associated with the IRRI program, although more than half had at one time intended to produce IRRI-designed machines. Some of the non-IRRI firms were drawn at random from existing industry lists, while others were placed in the group when errors were found in the preliminary list of IRRI-cooperating firms. The geographic distribution of the sample is shown in Figure 1.

Considerable diversity of firm sizes appeared to exist within the Philippine agricultural machinery industry (see Table 1.) Employment ranged from several one-man shops to three firms employing over 100 workers. Over half of the firms employed fewer than 20 workers. Despite their numerical dominance, these small firms accounted for only a fraction (16.3 percent) of total employment in the sample. The eight firms employing 50 or more provided 52.3 percent of total employment in the sample. A similar picture emerged in sales. Twelve of the 40 firms reporting had sales of ₱100,000 or less in 1980, and median sales was only ₱281,000. Ten large firms, eight of which also fall into the largest employment group, made sales of ₱1 M or more, and together they captured 86.8 percent of 1980 sales reported in the sample. The mean employment and sales for IRRI and non-IRRI firms are also reported in Table 1. These group means were not significantly different at the 90% confidence level.

The method of sales used by agricultural machinery producers reflected the distribution of firm sizes within the industry. Smaller firms tended to sell their products directly to end users. All but six of the sample firms made at least some sales directly to end users, and 68.2 percent sold half or more of their output by this method. In addition, over half the firms used some field salesmen. However, large firms, particularly those in Metro Manila, tended to rely on dealers and retail outlets, so a large portion of the total sales (48.5 percent) in the sample was made by these indirect methods. Direct sales accounted for 37.9 percent of sales and field salesmen for 13.6 percent.

The high degree of contact many firms had with their customers was consistent with the importance of customers as a source of new ideas for firms. Firms rated various possible sources of technology and new ideas on a scale from 1 (not important at all) to 4 (extremely important). The average rating for customers (3.5) was the highest of all the sources considered. Technical personnel within each firm was rated second (3.3), followed by IRRI (3.0). Judged least important on average were sub-contractors (1.3), patent documents (1.4) and suppliers (1.8).

THE VARIETY OF PRODUCT CHANGES

Another potentially important source of technology for the individual firm is the other firms producing the same or similar products. It was apparent in the survey interviews that the managers of most firms were quite familiar with the competing product designs being sold in their region. Firms felt little reservation about adopting ideas embodied in other products. Patents were not seen as an important obstacle to imitation, since most patent holders considered it unprofitable to prosecute patent infringements. It is possible, in an industry with plentiful information about the changes made by other firms and relatively low obstacles to copying, that a fairly homogenous product would emerge. Putting this possibility in terms of an extreme case, would all the product changes made by any firm in the industry also be made by every other firm?

To answer this question, a list was compiled of the changes made by the sample firms in three IRRI-designed machines -- the power tiller, portable thresher, and axial-flow thresher. Individual changes were grouped by the feature or component of the product being changed (e.g., all changes on the threshing drum were grouped together, and all changes on the blower formed a separate group). The results are presented in Table 2. The first row shows that for all three products, over 30 percent of the components changed by any firm in the sample were changed by only one firm. The components represented in the first two rows together, including over 60 percent of all the components changed in these products, were changed by at most two of the sample firms. The main conclusion to be drawn is that there was a high degree of individuality in the changes made by each firm. This is actually understated in Table 2, since even firms changing the same component often made quite different improvements. Instead of highly homogenous products, the industry has developed a variety of differentiated products appealing to different segments of each regional market. This variety allows farmers and other users to choose among the competing designs the machines with features most suitable to the particular agricultural conditions in which they operate.

CHARACTERISTICS OF INNOVATIVE FIRMS

A major purpose of this study was to shed light on the characteristics of firms active in improving product technology. Each firm was asked to list all changes made in its agricultural machinery products since 1975. When possible, this list was supplemented by and checked against an actual examination of the current product. The total number of these product changes serves as a rough indicator of the amount of product change implemented in each firm. Table 3 shows the distribution of the number of product changes across firms in the sample.

A preliminary analysis of the data has been made to determine what factors and firm characteristics are associated with a high degree of product change. In explaining product change, which can be thought of as output of the technology change process, an obvious factor to consider is the expenditures or effort devoted to product change, which can be in turn thought of as input into technology change. The standard measure of technology change input is research and development (R&D) expenditures. Eighteen of the sample firms reported some expenditure on R&D for 1980, averaging ₱42,790. The average over the whole sample was ₱16,745, or about 1.5 percent of 1980 sales. A difference of means test showed, as, expected, that firms conducting R&D made more product changes on average than firms not performing R&D, significant at the 90% confidence level.

Though only 40 percent of the sample firms reported any formal R&D expenditures, nearly all firms made some product change. This indicates that some technological effort was expended which was not captured in formal expenditures. In an attempt to better measure informal technology change efforts, firms were asked to report how many persons were engaged in various technical functions within the firm and estimate the percentage of their time spent on each of the functions. Included among the functions was the improvement of existing products. All but four firms reported some activity to improve their products, averaging the equivalent of one-third man-year per firm. The amount of time per firm was significantly and positively correlated with the number of product changes (see Table 4).

Other activities within the firm can also contribute, if less directly, to product change. In particular, other technical functions which require employees to identify or correct product problems, to deal analytically with production methods, to produce minor modifications requested by customers, or to think creatively about new products, can generate ideas and abilities useful in product change. Table 4 shows that, with the exception of adjustment work, each of these technical activities was significantly and positively correlated with the

number of product changes. Since activity levels in these technical functions were highly correlated with each other, it is difficult to assess the independent contribution of each. Nonetheless, some evidence is present that related technical activity yields benefits which spill int product change.

Several other factors were also examined for their relation with product changes (see Table 4). Firm size, represented by 1980 sales, proved positively correlated with product changes. The contemporary emphasis of the survey data made it impossible to determine whether product changes caused increased sales or whether large firms were better able to make changes. Interestingly, the number of years of experience a firm had accumulated in agricultural machinery production did not appear to affect the number of product changes. Two other variables, both of which may be considered as inputs into technology change, were significant. Firms were asked to estimate the average number of technical suggestions made by workers in a year, and firms receiving more suggestions tended to have more product changes. Within the sample of IRRI-cooperating firms, the number of hours of technical assistance rendered by IRRI personnel to the various firms was positively correlated with the number of product changes.

Several avenues of explanation have not yet been satisfactorily explored. First, it is possible to group product changes into major and minor changes, and it would be desirable to know what factors and firm characteristics are associated with each, particularly if they seem to differ for different types of change. Another measure of product change, the number of patents granted to each firm, has not been included in this analysis. Major changes and the number of patents are significantly correlated and appear to be more closely related to each other than to the number of minor changes. Using these finer distinctions and an additional measure of product change will extend the work reported here comparing the total numbers of changes made by various firms. A second avenue goes below the firm level to examine the number of changes made in individual products by the firms producing the product. Potentially, this approach offers greater insights than the firm level approach, since some of the variation across firms in total product changes is due to differences in product mix. Additionally, it will be possible to introduce into the analysis product level variables such as selling price and volume of production.

SUMMARY

It was argued above that LDCs can take full advantage of acquired technology only when it has been adapted to local conditions. This study has provided evidence that considerable capacity for product-improving technology change is present in the firms of the Philippine agricultural machinery industry. Because each firm tends to change a product in a different way, a variety of differentiated products are offered for sale, allowing users to select the machinery best suited to their needs. Large firms tend to make more product changes, but small firms can and normally do participate as well, whether or not they formally conduct research and development. Other technical activity within the firm, customer contact, worker suggestions, and assistance rendered by IRRI constitute four added sources of technology that appear to contribute to product change.

Table 1. Firm size in the agricultural machinery industry.

A. Employment

Range	No. of firms	% of firms	No. of employees	% of employees	Average employees per firm
1-9 employees	16	34.0	87	6.6	5.4
10-19 employees	10	21.3	126	9.6	10.6
20-49 employees	13	27.7	411	31.4	31.6
50 and above	8	17.0	685	52.3	85.6
Total	47	100.0%	1309	99.9%[a]	27.9

B. Sales (in thousand pesos)

Range	No. of firms	% to firms	1980 sales	% of sales	Average sales per firm
0 - 100	12	30.0	572.7	1.2	48
101 - 300	12	30.0	2,847.3	5.9	237
301 - 999	6	15.0	2,967.5	6.1	495
1,000 and above	10	25.0	41,951.0	86.8	4,195
Total	40	100.0%	48,338.5	100.0%	1,208

C. Size comparison of IRRI and non-IRRI cooperating manufacturers.

Firm type	No. of firms	Total employment	Average employment	No. of firms	1980 sales ('000 pesos)	Average sales ('000 pesos)
IRRI	28	907	32.4	21	35,610	1,696
Non-IRRI	19	402	21.2	19	12,728	670
Total	47	1,309	27.9	40	48,338	1,208

[a] Totals may not add to 100 percent due to rounding.

Table 2. Distribution of changed components by the number of firms changing the component.

	IRRI power tiller (11 firms)		IRRI portable thresher (14 firms)		IRRI axial-flow thresher (13 firms)	
	Number changed	%	Number changed	%	Number changed	%
Components changed by 1 firm	11	(57.9)	5	(27.8)	11	(57.9)
Components changed by 2 firms	3	(15.8)	5	(27.8)	2	(10.5)
Components changed by 3 firms	3	(15.8)	4	(22.2)	3	(15.8)
Components changed by 4 or more firms	2	(10.5)	4	(22.2)	3	(15.8)
Total components changed	19	(100.0)	18	(100.0)	19	(100.0)

Table 3. Distribution of firms by number of product changes.

Number of changes	Number of firms	Average number of changes
0	4	0
1 - 5	22	3.0
6 - 10	11	7.3
11 - 15	7	11.7
16 - 20	1	17.0
21 or more	1	23.0
Total	46	5.8

Table 4. Correlation of firm characteristics with product changes.

Variable	Average value	Estimated correlation coefficient	Significance confidence level
Product improvement	0.35 man-yr. equivalent	0.32	.05
Quality control	0.59 " "	0.47	.01
Maintenance & repairs	0.77 " "	0.68	.01
Adjustments to meet customers specifications	0.33 " "	0.15	*
Inventing new products	0.33 " "	0.29	.10
Improving production processes	0.34 " "	0.33	.05
1980 sales	₱1.15 million	0.54	.01
Agricultural machinery production experience	9.8 years	0.15	*
Worker suggestions	20.1 suggestions	0.45	.01
IRRI technical assistance since 1975	81.3 hours**	0.38**	.10**
[illegible]	[illegible]	0.47	.01

*Not significant at the .10 level.

**IRRI cooperating firms only.

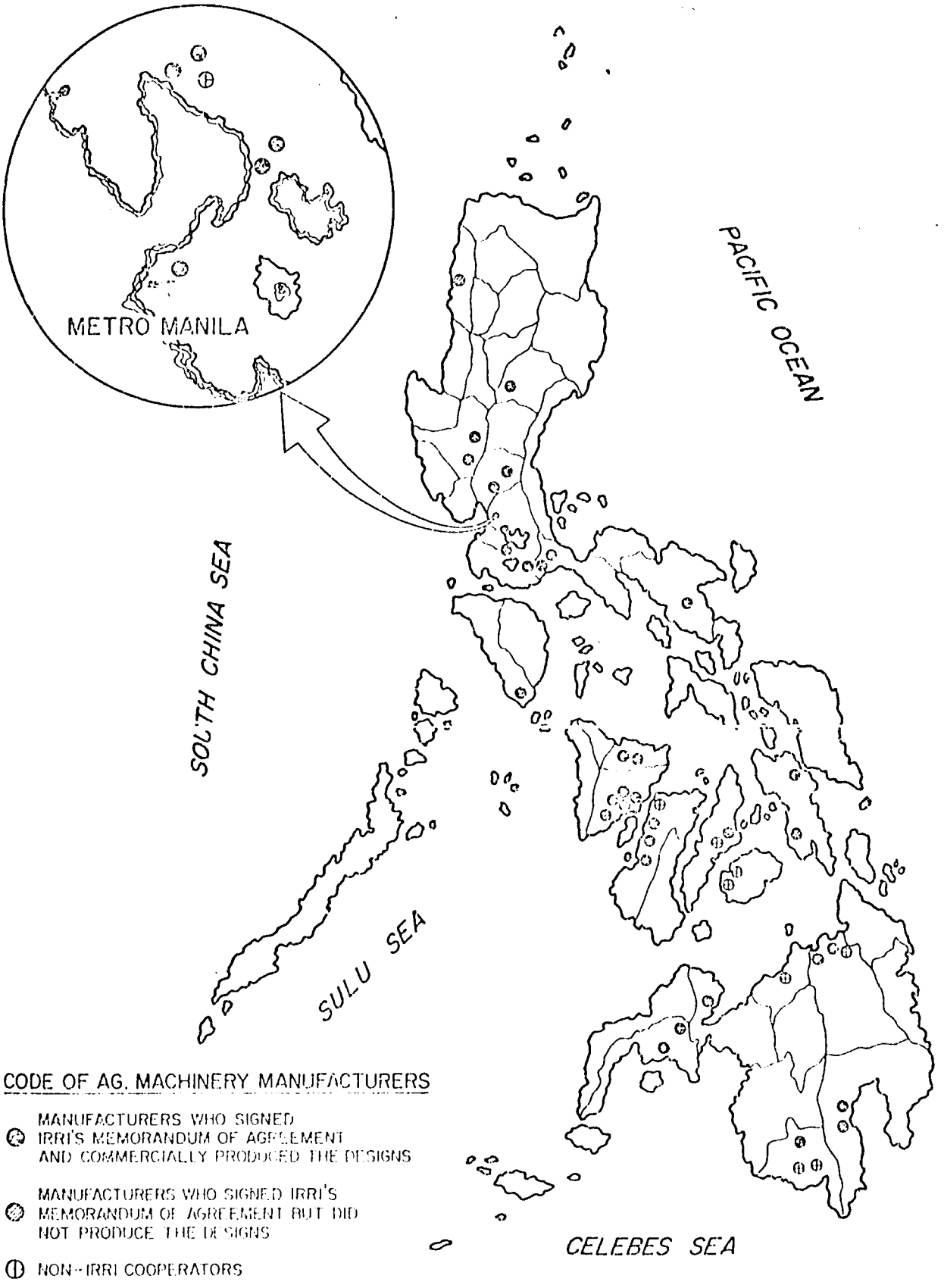

FIG. 1. AGRICULTURAL MACHINERY MANUFACTURERS IN THE PHILIPPINES.

I. Number of firms fabricating commercially produced agricultural machines by size and type.

MACHINES	IRRI COOPERATORS (Based on 28 firms surveyed)					NON-IRRI COOPERATORS (Based on 18 firms surveyed)				
	Firm's Size[1]					Firm's Size[1]				
	1-9	10-19	20-49	50 & above	Total	1-9	10-19	20-49	50 & above	Total
Axial flow thresher	2	3	4	5	14	1	2	1	1	5[2]
Portable thresher	3	4	4	4	15	-	-	1	1	2
Pedal thresher	1	-	-	-	1	1	1	1	-	3
Power tiller	4	5	4	1	14	4	-	1	2	7
Rice blower	1	-	1	1	3	1	1	-	1	3
TOTAL FIRMS[3]	7	7	7	6	27	5	2	2	2	11
	Note: One firm did not produce any of the listed designs.					Note: Eight firms did not produce any of the listed designs.				

[1]Size classification of firms is based on the total number of employment.

[2]Threshers fabricated by firms are the big, Cotabato-type (Presto-patented) machines.

[3]Figures under the 'total firms' column do not equal to the numerical sum of the numbers listed in each corresponding columns due to some firms fabricating more than one products.

II. 1980 Production of commercially produced agricultural machinery by firm's size and type

MACHINES	IRRI COOPERATORS (Based on 28 firms surveyed)					NON-IRRI COOPERATORS (Based on 19 firms surveyed)				
	Firm's Size					Firm's Size				
	1-9	10-19	20-49	50 & above	Total	1-9	10-19	20-49	50 & above	Total
Axial flow thresher	30	137	22	656	844[a]	4	12	30	200	246[b]
Portable thresher	54	120	110	718	1002[c]	-	-	15	50	65[d]
Pedal thresher	-	-	-	-	0[e]	100	108	-	-	208[f]
Power tiller	22	352	115	905	1394[g]	53	-	20	945	1018[h]
Rice blower	-	-	80	100	180[i]	4	10	-	10	24
TOTAL	106	609	327	2379	3420	161	130	65	1025	1561

[a]Figures based on 10 firms with reported production; 3 firms did not give figures and 1 firm stopped production in 1980.

[b]Threshers are the big, Cotabato-type (Presto-patented) machines.

[c]From 12 firms with reported production. Two firms did not give any figures and one firm stopped production in 1980.

[d]A modified IRRI portable thresher or smaller version of threshers mentioned at b.

[e]One IRRI cooperator listed in Table I produces the machine in 1981.

[f]One non-IRRI cooperator did not give any figures.

[g]Figures based on 11 firms only.

[h]Includes 948 units of the turtle-type power tiller.

[i]Based on 2 firms only.

III. % rating on the importance of the different sources of technology and new ideas.

SOURCES	IRRI Cooperators (Based on 28 firms surveyed)					Non-IRRI Cooperators (Based on 29 firms surveyed)				
	Degree of Importance					Degree of Importance				
	A	B	C	D	Total	A	B	C	D	Total
1. Technologists within firm	3.7	18.5	14.8	63.0	100.0	0	18.7	31.3	50.0	100.0
2. Professional trade journals & other technical magazines	7.4	44.4	40.7	7.5	100.0	12.5	37.5	25.0	25.0	100.0
3. Raw material suppliers	48.0	25.9	14.8	11.3	100.0	56.3	18.7	18.7	6.3	100.0
4. Customer's ideas	0	0	51.9	48.1	100.0	0	0	31.3	62.4	100.0
5. Sub-contractor's ideas	66.7	18.5	14.8	0	100.0	93.8	0	6.2	0	100.0
6. Workers' suggestions	11.0	18.5	59.3	14.8	100.0	0	50.0	43.8	6.2	100.0
7. IRRI consultants	0	11.1	3.7	85.2	100.0	50.0	25.0	12.5	12.5	100.0
8. Non-IRRI consultants	44.4	25.9	18.5	11.2	100.0	68.8	12.5	6.2	12.5	100.0
9. Patent documents	81.5	14.8	0	3.7	100.0	87.6	6.2	6.2	0	100.0

A - not important at all

B - somewhat important

C - quite important

D - extremely important

COMPARATIVE DATA FOR IRRI AND NON-IRRI FIRMS

ITEMS	IRRI FIRMS		NON-IRRI FIRMS	
	Responding Firms, N	%	Responding Firms, N	%
1. Procedure manuals, without	20	74.0	13	68.4
with	7	26.0	6	31.6
	27	100.0	19	100.0
2. No. of Printed forms				
0-5	16	59.0	13	68.0
6-10	6	18.0	3	16.0
11 & above	6	23.0	3	16.0
	28	100.0	19	100.0
3. No. of employee w/ BS degree				
0	9	32.0	12	63.0
1-2	12	57.0	6	32.0
3	7	11.0	1	5.0
	28	100.0	19	100.0
4. QC Inspection: regular	4	69.0	2	87.5
random	9	31.0	14	12.5
	13	100.0	16	100.0
5. No. of years of experience in Agric. Machinery Prodn.	28	7.0 yrs ave	19	14.0 yrs ave.
6. Total no. of product changes made	28	186 (ave.-7)	18	83 (ave.-7)
7. Total patents granted:				
INV.	28	2 pat.	18	1 pat.
UM		36 pat.		22 pat.
Total		38		23
Ave.		1.5		1.2

Comparative data cont'd.

ITEMS	IRRI FIRMS		NON-IRRI FIRMS	
	Responding Firms, N	%	Responding Firms, N	%
8. Total Technologist employed	28	148 (Ave.-5)	18	106 (Ave.-6)
9. Total 1980 estimated budget for research and development	27	₱1.305 M (Ave. ₱48,000)		₱422,500 (Ave. ₱22,000)
10. Workers' suggestion accepted, 1980 total implemented	24	611 (Ave.-25) 44	14	154 (Ave.-11) 55